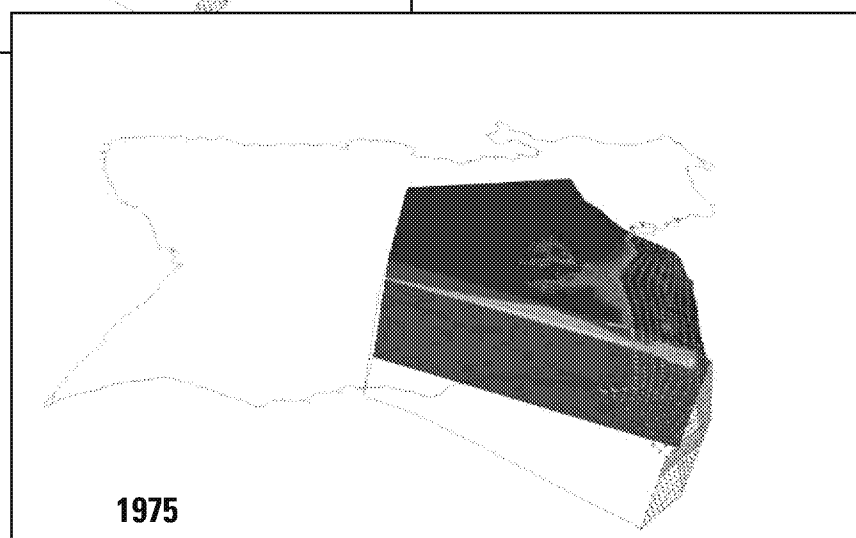
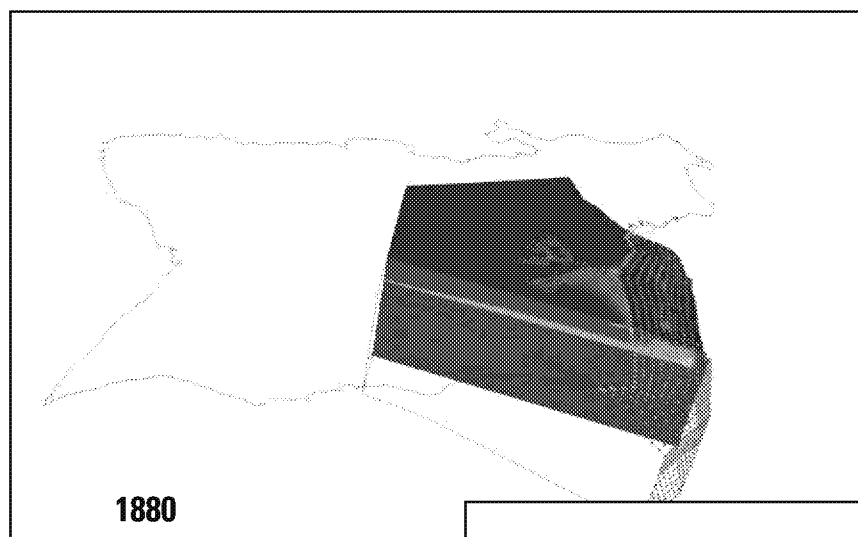


Prepared in cooperation with the Honolulu Board of Water Supply

Numerical Simulation of the Effects of Low-Permeability Valley-Fill Barriers and the Redistribution of Ground-Water Withdrawals in the Pearl Harbor Area, Oahu, Hawaii



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Model Limitations

The numerical model developed for this study simulates water levels and salinity on a regional scale and may not accurately predict either the pumping water level at an individual well or the salinity of water pumped from that well. Salinity of water pumped from a well may be controlled by local heterogeneities in the aquifer that are not represented in the model, and the level of model discretization affects the numerical accuracy with which transport mechanisms are simulated. The model has several other limitations for predictive purposes because of the various assumptions used and possible uncertainties in input data. These limitations are discussed below.

Differences between measured and simulated water levels and salinity profiles are greater in some areas than others, which may reflect uncertainties in the recharge or withdrawal estimates, boundary conditions, assigned parameter values in the model, or representations of the different hydrogeological features in the model. Recharge estimates in Hawaii generally are based on water-budget computations that could be improved with a better understanding of the spatial distributions of rainfall, evapotranspiration, runoff, and land-cover characteristics. Additional studies that could reduce uncertainties include: (1) directly measuring recharge using field lysimeters, (2) measuring changes in soil moisture below the plant root zone, (3) quantifying increases in the chloride concentration of infiltrating water caused by evapotranspiration, (4) measuring ground-water discharge with offshore seepage meters, and (5) developing an integrated surface-water/ground-water model. Improved recharge estimates in the study area will lead to improved estimates for parameter values in the numerical ground-water model and greater confidence in model results. Withdrawals represented in the model were based on available information. Unreported withdrawals and uncertainties in reported withdrawals that cannot be quantified also affect the accuracy of model results.

For this study, no-flow boundaries were assigned in the east and west, which precludes movement of ground water across these boundaries. Although some flow likely takes place across these boundaries, the amount cannot be quantified without expanding the modeled area.

The distributions of parameter values assigned in the model were kept simple to avoid creating an overly complex model that could not be justified on the basis of existing information. Heterogeneity in the ground-water system likely exists but is currently poorly understood. Values assigned to model parameters generally were based on existing estimates. However, some of these parameter values may be poorly known. Improved estimates of the distribution of hydraulic characteristics in the study area can be obtained using controlled aquifer tests as well as by careful monitoring of pumping and water-level conditions throughout the aquifer. Accurate pumping data in conjunction with water-level drawdown and recovery data can be used for calibration of a numerical ground-water

flow model, particularly during periods when recharge does not vary.

The geometrical representation of the valley-fill barriers, caprock, and Waianae confining unit also were kept simple for the model. Because of uncertainty in the configuration of the valley-fill barriers, different configurations were tested in a sensitivity analysis. The sensitivity analysis indicated that model results could be improved in some places by adjusting valley-fill configurations. Our understanding of the geometry of the valley-fill barriers can be improved using surface geophysical techniques in conjunction with drilling additional monitor wells within the valleys (see for example R.M. Towill Corporation, 1978). In addition, careful monitoring of water levels on opposite sides of valley-fill barriers can provide insight as to the hydrologic effectiveness of the barriers.

For this study, the coastal caprock was represented as a homogeneous zone of low permeability except near the top of the caprock, where a high-permeability limestone unit was modeled. Other high-permeability zones likely exist in the caprock but they are poorly understood and were not represented in the model for this study. The Waianae confining unit was represented in the model as a vertical unit located near the sea-level contact between Waianae Volcanics and Koolau Basalt. Although the Waianae confining unit may dip about 10° away from the Waianae Volcano toward the east, it was represented in the model as a vertical unit because of uncertainty in the location of the confining unit eastward of the sea-level contact between Waianae Volcanics and Koolau Basalt.

Flow of water at the vertical seaward boundary of the model, below the caprock, was controlled by the hydraulic conductivity of the row of elements at the boundary. The ease with which saltwater enters the model at this boundary has an effect on the transient response of the system to changes in recharge and withdrawals. Extension of the model farther offshore may reduce the sensitivity of the model to the assigned hydraulic conductivity at the seaward boundary.

Two modeling artifices were incorporated to improve numerical stability in the model: (1) shallow zones (top two elements at most) of high dispersivity were created near zones of discharge, and (2) withdrawal from selected Maui-type shafts with infiltration tunnels was represented at more than one model node. These modeling artifices could be relaxed in future models that have finer discretization, although neither of these artifices likely affect the overall conclusions of this study.

Confidence in model results can be improved by addressing the limitations described in this section. In particular, improved estimates of recharge and the distribution of model parameters likely will lead to better model reliability.

Summary

The aquifer in the Pearl Harbor area of southern Oahu is the most heavily used aquifer in the State of Hawaii. For